

Mathematicians calculate chances of actually discovering King Richard III were less than 1%

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Back row (l to r): Dr Clive Rix, Junjie Wu. Front row (l to r): Gloriose Hitimana, Lucie Mungapen, Sukhdeep Rana.

Mathematics students at the University of Leicester have calculated that archaeologists had less than a 1 percent chance of finding King Richard III when they began their historic search.

And they worked out that the chances of discovering him on the very first day – as the archaeologists did – were just 0.0554 per cent, or odds of 1,785 to 1 against!

But, thankfully, the discovery was not entirely left to chance –the world-

class research, planning, experience and expertise of the University of Leicester archaeologists reduced the odds against them.

It is now known that the team from the University of Leicester discovered the King following detailed research that helped them narrow down the possible location of the Grey Friars Church and [burial site](#).

A detailed desk-study produced before the project began pinpointed the options available to the archaeologists who used over 30 years' experience of digs in Leicester to work out the best places for the trenches as well as recognising the choir of the church where Richard was found - but there was a very high risk that his remains were no longer there or were under a part of the site not available for investigation.

As part of a maths project, [undergraduate students](#) on the [Business Applications](#) of Mathematics module were asked to work out the probability of the University of Leicester archaeologists finding the remains at the time they started the investigation. They concluded that there only a 0.84% chance of the team discovering Richard - or about 120 to 1 against.

And they further calculated:

- the chances of Richard having been buried in the Grey Friars church were about 85%
- there was about a 98% chance that the location of the Grey Friars precinct had been identified with sufficient accuracy
- only 2,322m² of the total area of the Grey Friars precinct of 13,648m² (about 17%) was available for investigation. The students thought the chances of the choir –where Richard was reputed to have been buried - being in the available area were

about 25%.

- The skeleton might not have survived, even if it were in the available area. The students assessed the chances of the body still being there (if it had been there at all) as about 66%.
- One of the most difficult chances to assess was that the investigation carried out would identify the choir. The students assessed the chances of the investigation finding the choir, if it were there, at about 15% and the chances of finding the grave within the choir if the choir were found at 80%.
- The students considered that the odds on being able to identify the skeleton as Richard's were about 50%.

Dr Clive Rix, a visiting lecturer in the Department of Mathematics, said: "The odds of actually finding King Richard III were very low indeed. Any commercial organisation would be looking for the potential of fairly spectacular returns to justify an investment with such a low chance of success – but, of course, this was not a commercial venture.

"Rather it was a research project conducted by a world-class team from the University of Leicester. The fact that Richard was found at all is a testament to the skill of the archaeological team that spearheaded this Search and the expertise that resides across different areas of this University – plus, of course, a bit of luck. "

Dig supervisor Mathew Morris, of the University of Leicester, was the first person to discover the remains. He said: "Had the first trench been laid just 50cm to the east of where it actually was - we might never have found Richard."

The University announced on the 4 February that the skeleton discovered in the Grey Friars car park in August 2012 was indeed that of [King Richard III](#), the last Plantagenet King of England.

The University of Leicester led the Search for Richard III, working with Leicester City Council and in association with the Richard III Society.

The archaeological team dug three trenches in the car park of the Grey Friars precinct – and in fact discovered Richard on the first day of the dig. However, the identification could not occur until an exhumation licence was granted and the team was able to work out the location of the burial on the basis of information from other trenches that were dug.

Dr Rix added: "As part of their course, students look at applications of mathematics to current issues in business, presented by people currently working in those areas. Assessing risk on the basis of uncertain information is an important aspect of management. We thought this would be nice way to introduce the subject, as it was a very topical issue.

"Of course, we now know that Richard was there all along, so this is not a probability like the probability of getting 'heads' if you toss a coin. This is more like the odds in a horse race - after the race, you know which horse has won but before it starts you can still assess the odds against each horse winning.

"In this particular project there were only two outcomes and one of them – 'we won't find him' – was a very short odds favourite."

Lucie Mungapen (21) from Le Mans, France, is one of the students who worked on the project. She said: "The Richard III challenge was a very interesting and for sure the funniest project I had to do so far. I have been able to experience team work and to work on a real-life project for the first time. I can't wait to start working for real now!"

Richard Buckley, the lead archaeologist on the project from the University of Leicester, said: "I always said finding Richard was a long shot!"

The students had to assess, based on all the available evidence:

- the odds on the historical accounts that Richard had been buried in the Grey Friars church being accurate;
- the odds on the archaeologists being able to identify the location of the church;
- the odds on the church being in a part of the site that was available for excavation (given that most of it is now covered by modern buildings and roads);
- the odds on the skeleton still being there (if it had been there at all);
- the odds on finding the church, the choir within the church and the grave within the choir, given the very small length of trench that could be afforded;
- the odds on scientific analysis being able to identify the skeleton if found.

How the calculation was made:

The students adopted the following approach.

Firstly, break down the problem into the different assumptions that had to be satisfied if Richard's skeleton were to be found and identified. They then, on the basis of all the information available, assessed the odds on it being satisfied. That required the following steps:

1. They had to assess how likely it was that Richard was indeed buried in the Grey Friars church in the first place. Several historians recorded this shortly after the event, including John Rous and Polydore Vergil. They were often writing from different perspectives and so the agreement can be regarded as significant. There is also an account of Henry VII setting aside money to pay for an alabaster tomb for Richard over his grave in

the Choir of Grey Friars church. The students thought the chances of Richard having been buried in the Grey Friars church were about 85%.

2. They next had to decide how likely it was that the archaeologists could accurately identify the location of the Grey Friars Church. "The earliest Leicester maps date back to the 1700s," explained Richard Buckley, lead archaeologist on the project, "but the first most reliable map that was made from a survey of the area dates to 1741. This was the one we used." This map shows the location of the Grey Friars precinct but not the layout of the original buildings inside it, which had been destroyed after the dissolution of the monasteries 200 years earlier. Comparison of the map with modern maps showed that the surviving streets and buildings were accurately recorded on the earlier map, so the students assessed that there was about a 98% chance that the location of the Grey Friars precinct had been identified with sufficient accuracy.

3. One of the main problems was that most of the Grey Friars precinct had been built over, so only 2,322m² of the total area of the Grey Friars precinct of 13,648m² (about 17%) was available for investigation. Fortunately, many of the unavailable areas were in parts of the site where the church was unlikely to be found. Mediaeval friaries followed a fairly common plan: "there would be a square courtyard or 'cloister garth' ranged around which would be a chapter house and dormitory (normally on east side), a church (on north or south sides) a refectory and a cellarer's range (usually west)" said Mr Buckley. The church would probably not have been on the very edge of the site or on the western edge so, despite the relatively small area available for excavation, the students thought the chances of the choir being in the available area were about 25%.

4. The skeleton might not have survived, even if it were in the available area. But the soils in this area are good for the preservation of the bones and most of that part of the site available for investigation has never

been disturbed. After the Friary was abandoned a mansion was built on the site, with gardens and orchards. The part of the site available for excavations was in the latter and it is unlikely that the skeleton would have been disturbed by cultivation. Since then building development has been round the edge of the site, mainly under the area that is currently built on. A story that the skeleton was dug up and thrown in the river after the burial was largely discounted. The students assessed the chances of the body still being there (if it had been there at all) as about 66%.

5. One of the most difficult chances to assess was that the investigation carried out would identify the choir. The total area actually investigated by trenching was only 172m², 7½% of the area available. However, the skill and experience of the archaeologists in deciding where to place the trenches – and in particular using the information from each trench to guide the placement of subsequent trenches – has to be taken into account. It was a matter of judgement, as well as good luck, that the first trench encountered the church (though it could not be identified as such until careful placing of the second trench identified the east side of the cloister) but the placement of the trench meant it would have been unlucky indeed not to encounter something. Once the choir had been identified, it would have been relatively straightforward to carry out a more detailed exploration of it. Taking everything into consideration, the students assessed the chances of the investigation finding the choir, if it were there, at about 15% and the chances of finding the grave within the choir if the choir were found at 80%.

6. If his skeleton were found, it still had to be identified as Richard's. A number of tests were possible, some of which would be reasonably conclusive and some would merely strengthen the case that Richard had been found. The mitochondrial DNA test would be the most compelling, provided a suitable sample could be extracted from the skeleton, and the fact that a descendant through 16th generations of the maternal line had already been found made this a reasonable prospect. Radiocarbon dating

could show that the skeleton was definitely not that of Richard if the dates had been inconsistent but only provide supporting evidence otherwise, as its accuracy was unlikely to be better than to within 80 years. The condition of the skeleton – did it show evidence of wounds consistent with dying in battle, and did it show evidence of the deformity reported by Shakespeare and others, if indeed such deformity existed, given the efforts to blacken Richard's name after his death? A range of tests was available but many of them would give at best supporting evidence. The students considered that the odds on being able to identify the skeleton as Richard's were about 50%.

Since all these conditions have to be satisfied and they are independent of each other, the percentages can be multiplied together to give the overall chance of finding and identifying Richard at 0.84% - or about 120 to 1 against.

Odds of finding Richard on Day 1:

There were 12 days of investigation, plus a contingency day. If all these days had been equally likely then the probability of finding him on the first day would have been one twelfth of the total [probability](#). However, the later days would have been more likely as the [archaeologists](#) could use the information from the first trench to inform their decisions about later trenches, thus improving their chances, so the mathematicians have discounted the one twelfth by 20%. That means the chances of finding him on the first day were about 6.6% of 0.84% - 0.0554% - about 1,785 to 1 against.

Provided by University of Leicester

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